CHAPTER 3

Criteria Pollutants — Metropolitan Area Trends

http://www.epa.gov/oar/aqtrnd98/chapter3.pdf

This chapter presents status and trends in criteria pollutants for Metropolitan Statistical Areas (MSAs) in the United States. The MSA trends and status give a local picture of air pollution and can reveal regional patterns of trends. Such information can allow one to gauge the air pollution situation where they live, although not all areas in the country are in MSAs, and not all MSAs are included here. A complete list of MSAs and their boundaries can be found in the Statistical Abstract of the United States.[1] The status and trends of metropolitan areas are based on four tables found in Appendix A (A-13 through A-16). Table A-13 gives the 1998 peak statistics for all MSAs, providing the status of the most recent year. Ten-year trends are shown for the 258 MSAs having data that meet the trends requirements explained in Appendix B. Table A-14 lists these MSAs and reports criteria pollutant trends as "upward" or "downward," or "not significant." These categories are based on a statistical test, known as the Theil test, which is described later in this chapter.

Another way to assess trends in MSAs is to examine Air Quality Index (AQI) values.[2,3] The AQI is used to present daily information on one or more criteria pollutants to the public, in an easily understood format and in a timely manner. Tables A-15 and A-16 list the number of days with AQI values greater than 100 (unhealthy for sensitive groups) for the nation's 94 largest metropolitan areas (population greater than 500,000). Table A-15 lists AQI values based on all pollutants, while Table A-16 lists AQI values based on ozone alone. The tables listing Pollutant Standard Index (PSI) data from previous reports may not agree with the tables in this report because the new AQI is completely different. These changes are presented in more detail later in this chapter.

For several reasons, these tables are incomplete with respect to MSAs and data. For example, not every MSA appears in the tables and data for all pollutants does not appear for each MSA. This is because the MSA population is so small, or the air quality is so good, that AQI reporting is not required. Some data entries in Table A-13 are listed as "ND," or no data. Not all criteria pollutants are measured in all MSAs. Ambient monitoring for a particular pollutant may not be conducted if there is no problem. This is why data for some MSAs are designated as "ND" (no data) for those pollutants. In addition, there are MSAs with too little monitoring data for trends analysis purposes (see Appendix B). Finally, there are MSAs that do not meet the population threshold required for inclusion in Tables A-15 and A-16.

Status: 1998

The air quality status for MSAs can be found in Table A-13 (for related information, see Table A-12, peak concentrations for all counties with monitors that reported to the Aerometric Information Retrieval System (AIRS) database). Table A-13 lists peak statistics for all criteria pollutants measured in an MSA. Peak statistics for MSAs are found in Table A-13, which shows that 173 areas had peak concentrations exceeding standard levels for at least one criteria pollutant. The number of these areas increased 34 percent over the count from 1997 data (129 areas). The increase can be attributed to the many areas that have peak 8-hour ozone concentrations just above the level of the 8-hour ozone standard in 1998. These 173 areas represent 64 percent of the U.S. population. Similarly, there were 14 areas representing 14 percent of the population that had peak statistics that exceeded two or more standards. Only one area, (Las Vegas, NV-AZ) representing less than 1 percent of the U.S. population, had peak statistics from three pollutants that exceeded the respective standards. The high value for PM_{10} is due to area sources (dust) for this MSA.

There were no areas, however, that violated four or more standards.

Trends Analysis

Table A-14 displays air quality trends for MSAs. The data in this table are average statistics of pollutant concentrations from the subset of ambient monitoring sites that meet the trends criteria explained in Appendix B. A total of 258 MSAs have at least one monitoring site that meet these criteria. As stated previously, not all pollutants are measured in every MSA.

From 1989–1998, statistics related to the NAAQS were calculated for each site and pollutant with available data. Spatial averages were obtained for each of the 258 MSAs by averaging these statistics across all sites in an MSA. This process resulted in one value per MSA per year for each pollutant. Although there are seasonal aspects of certain pollutants and, therefore, seasonality in monitoring intensity for different MSAs, the averages for every MSA and year provide consistent values with which to assess trends.

Since air pollution levels are affected by variations in meteorology, emissions, and day-to-day activities of populations in MSAs, trends in air pollution levels are not always well defined. To assess upward or downward trends, a linear regression was applied to these data. An advantage of using the regression analysis is the ability to test whether or not the upward or downward trend is real (significant) or just a chance product of year-to-year variation (not significant). Since the underlying pollutant distributions do not meet the usual assumptions required for common least squares regression, the regression analysis was based upon a nonparametric method commonly referred to as the Theil test.[5,6,7] Because linear regression estimates the trend from changes during the entire 10-year period, it is possible to detect an upward or downward trend even when the concentration level of the first year equals the concentration level of the last year. Also, this method uses a median estimator which is not influenced by a single extreme value.

Table 3-1. Summary of MSA Trend Analyses, by Pollutant

Trend Statistic		Total # MSAs	# MSAs Up	# MSAs Down	# MSAs with No Significant Change
CO	Second Max 8-hour	139	0	104	35
Lead	Max Quarterly Mean	90	1	61	28
NO_2	Arithmetic Mean	97	4	44	49
Ozone	Fourth Max 8-hour	198	13	25	160
Ozone	Second Daily Max 1-hour	198	11	23	164
PM_{10}	Weighted Annual Mean	211	1	152	58
PM_{10}	90th Percentile	211	0	132	79
SO_2	Arithmetic Mean	148	0	103	45
SO_2	Second Max 24-hour	148	0	91	57

Table 3-1 summarizes the trend analysis performed on the 258 MSAs by pollutant. It shows that there were no upward trends in carbon monoxide (CO) and sulfur dioxide (SO_2 maximum daily mean) at any of the MSAs over the past decade. Summarized by area, of the 258 MSAs, 221 had downward trends in at least one of the criteria pollutants, and only 21 had upward trends. A closer look at these 21 MSAs reveals that most are well below the standard levels for the respective pollutant, meaning that their upward trends are not immediately in danger of exceeding the standard levels. The areas with a significant upward trend that were near or exceeding a standard level all involved 8-hour ozone. Overall, these results demonstrate significant improvements in urban air quality over the past decade.

Geographical summaries of the trends analysis show variations from one region to another. Trends for CO show that while most of the nation is experiencing a downward trend, there are isolated areas where the trend is nonsignificant (Southern Pennsylvania, Washington, Oregon, Nebraska, Iowa, and Texas). Trends for lead (Pb) are down for almost all of the country (one upward trend in the Seattle area). Trends for NO_2 are either down or nonsignificant with a small pocket of upward trends in Texas. Based on the 1-hour ozone standard, most MSAs have a nonsignificant trend, with downward trends showing up in the West (California, Nevada, and Colorado) and upward trends showing up in the East. Trends based on the 8-hour ozone standard show more areas with 1998 data above the level of the revised standard. Trends for the annual form of the PM_{10} standards show the PM_{10}

Table 3-2. AQI Categories, Colors, and Ranges

Category	AQI	O_3 (ppm) 8-hour	O_3 (ppm) 1-hour	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	CO (ppm)	SO_2 (ppm)	NO_2 (ppm)
Good	0 – 50	0.000 – 0.064	(2)	0.0 - 15.4	0 – 54	0.0 – 4.4	0.000 – 0.034	(3)
Moderate	51 – 100	0.065 – 0.084	(2)	15.5 – 40.4	55 – 154	4.5 – 9.4	0.035 – 0.144	(3)
Unhealthy for Sensitive Groups	101 – 150	0.085 – 0.104	0.125 – 0.164	40.5 – 65.4	155 – 254	9.5 – 12.4	0.145 – 0.224	(3)
Unhealthy	151 – 200	0.105 – 0.124	0.165 – 0.204	65.5 – 150.4	255 – 354	12.5 – 15.4	0.225 – 0.304	(3)
Very unhealthy	201 – 300	0.125 – 0.374	0.205 – 0.404	150.5 – 250.4	355 – 424	15.5 – 30.4	0.305 – 0.604	0.65 – 1.24
Hazardous	301 – 400 401 – 500	(1) (1)	0.405 – 0.504 0.505 – 0.604	250.5 – 350.4 350.5 – 500.4	425 – 504 505 – 604	30.5 – 40.4 40.5 – 50.4	0.605 – 0.804 0.805 – 1.004	1.25 – 1.64 1.65 – 2.04

1. No health effects information for these levels–use 1-hour concentrations.

2. One hour concentrations provided for areas where AQI based on one hour values might be more cautionary.

3. NO_2 has no short term standard but does have a short term “alert” level.

weighted annual mean has mostly downward trends with the exception of one area in Pennsylvania. Trends based on the daily SO_2 form of the standard are mostly down for the nation. The majority of MSAs with downward trends are in the northern half of the nation, while the majority of the MSAs with non significant trends are in the southern half of the nation.

The Air Quality Index

The Air Quality Index (AQI) provides information on pollutant concentrations for ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. The AQI is “normalized” across pollutants so that an AQI value of 100 represents the level of health protection associated with the national health-based standard for each pollutant and an AQI value of 500 represents the level at which the pollutant causes significant harm . This Index has been adopted internationally and is used around the world to provide the public with information on air pollutants.

EPA has revised its Air Quality Index to enhance the public’s understanding of air pollution across the nation. Previously known as the Pollutant Standards Index (PSI), this uniform air quality index is used by state and local agencies for reporting on daily air quality to the public. The revised Index can also serve as a basis for programs that encourage the public to take action to reduce air pollution on days when levels are projected to be of concern to local communities. A new national Internet website, AIRNOW (www.epa.gov/airnow), which includes “real time” air quality data and forecasts of summertime smog levels in many states, uses the AQI categories, colors, and descriptors to communicate information about air quality.

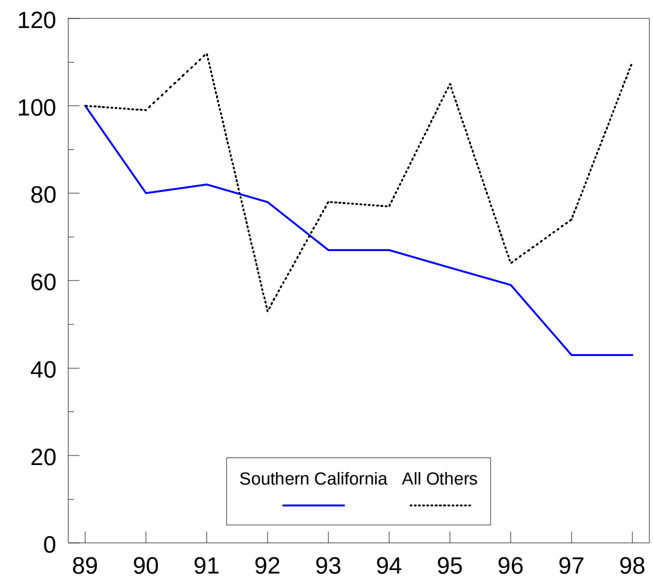
AQI values are derived from pollutant concentrations. They are reported daily in all MSAs of the United States with populations exceeding 350,000. The AQI is reported as a value between zero and 500 and a descriptive name (e.g., “unhealthy for sensitive groups”) and is featured on local television or radio news programs and in newspapers.

Based on the short-term NAAQS, Federal Episode Criteria,[8] and Significant Harm Levels for each pollutant,[9] the AQI is computed for PM_{10}, SO_2, CO, O_3, and NO_2. Lead is the only criteria pollutant not included in the index because it does not have a short-term NAAQS, a Federal Episode Criteria, or a Significant Harm Level. Since the AQI is a tool used to communicate pollution concerns to a wide audience, there are also colors linked to the general descriptors of air quality. The six AQI color categories, their respective health effects descriptors, index ranges, and corresponding concentration ranges are listed in Table 3-2. EPA has also developed an AQI logo (Figure 3-1) to increase the visibility of the AQI in reports and also alert the public that the AQI is based on the uniform index throughout the country.

The AQI integrates information on criteria pollutant concentrations across an entire monitoring network into a single number that represents the worst daily air quality experienced in an urban area. For each of the criteria pollutants, concentrations are converted into an index value between zero and 500. The pollutant

Figure 3-1. Air Quality Index logo.

Figure 3-2. Number of days with AQI values > 100, as a percentage of 1989 value.



with the highest index value is reported as the AQI for that day. Therefore, the AQI does not take into account the possible adverse effects associated with combinations of pollutants (i.e., synergism).[2,3]

An AQI value greater than 100 indicates that at least one criteria pollutant (NO_2 has no short-term standard) exceeded the level of the standard, therefore, designating air quality to be in the "unhealthy for sensitive groups" range on that day. Relatively high AQI values activate public health warnings. For example, an AQI above 200 initiates a First Stage Alert at which time sensitive populations (e.g., the elderly and persons with respiratory illnesses) are advised to remain indoors and reduce physical activity. An AQI over 300 initiates a Second Stage Alert at which time the general public is advised to avoid outdoor activity.

EPA has changed the name of the Pollutant Standards Index to the Air Quality Index. The revised index adds an additional air quality category just above the level of the standard. Previously, values from 101–200 were characterized "unhealthful." The revised index establishes a category from 101–150 characterized as "unhealthy for sensitive groups," and a category of 151–200 as "unhealthy."

When air quality is "unhealthy for sensitive groups," EPA has added a corresponding requirement to report a pollutant-specific statement indicating what specific groups in the population are most at risk. For example, when the AQI is above 100 for ozone the AQI report will contain the statement "Children and people with asthma are the groups most at risk."

To the extent that state and local agencies use colors to communicate AQI values, specific colors are required. For instance, any agency that chooses to use colors to communicate such values must represent the Index values of 151–200 as "red." Examples of the use of color in Index reporting include the color bars that appear in many newspapers, and the color contours of the ozone map found on the AIRNOW website.

The revised Index includes a new sub-index for 8-hour average ozone concentrations and 24-hour concentrations of fine particulate matter. These changes to the Index are based on health effects information from the review of the ozone and particulate matter standards, as well as information and feedback provided by state and local agencies and the public.

The AQI includes changes to the sub-indices for 1-hour average ozone concentrations, particulate matter (PM_{10}), carbon monoxide and sulfur dioxide to reflect the addition of the new air quality category of "unhealthy for sensitive groups."

Summary of AQI Analyses

Since an AQI value greater than 100 indicates that the level for at least one criteria pollutant has reached levels where people in sensitive groups are likely to suffer health effects, the number of days with AQI values greater than 100 provides an indicator of air quality in urban areas. Figure 3-2 shows the trend in the number of days with AQI values greater than 100 summed across the nation's 94 largest metropolitan areas as a percentage of the 1989 value. Because of their magnitude, AQI totals for Los Angeles, Riverside, Bakersfield, and San Diego are shown separately as Southern California. Plotting these values as a percentage of 1989 values allows two trends of different magnitudes to be compared on the same graph. The long-term air quality improvement in southern California urban areas is evident in this figure. Between 1989 and 1998, the total number of days with AQI values greater than 100 decreased 57 percent in southern California but actually rose 10 percent in the remaining major cities across the United States. While five criteria pollutants can contribute to the AQI, the index is driven mostly by ozone. [*Note:* NO_2 is rarely the highest pollutant measured because it is not calculated for AQI values below 201; and NO_2 values in this range have not been recorded in the United States for at least five years.]

AQI estimates depend on the number of pollutants monitored as well as the number of monitoring sites where data are collected. The more pollutants measured and sites that are available in an area, the better the estimate of the AQI for a given day. Ozone accounts for the majority of days with AQI values above 100, but is collected at only a small number of sites in each area. Table A-16 shows the number of days with AQI values greater than 100 that are attributed to ozone alone. Comparing Tables A-15 and A-16, the number of days with an AQI above 100 are increasingly due to ozone. In fact, the percentage of days with an AQI above 100 due to ozone have increased from 92 percent in 1989, to 97 percent in 1998. This increase reveals that ozone increasingly accounts for those days above the 100 level and reflects the success in achieving lower CO and PM_{10} concentrations. However, the typical one-in-six day sampling schedule for most PM_{10} sites limits the number of days that PM_{10} can factor into the AQI determination.

References

1. *Statistical Abstracts of the United States*, 1998, U.S. Department of Commerce, U.S. Bureau of the Census.

2. *Measuring Air Quality, The Pollutant Standards Index*, EPA-451/K-94-001, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1994.

3. *Code of Federal Regulations, 40 CFR Part 58, Appendix G.*

4. Note: Although the results are summarized in the report for comparison purposes, the intent of publishing Tables A-14 through A-16 is to present information on a localized basis, to be used on a localized basis (i.e., one MSA at a time). Therefore, no attempt was made to adjust the Type I error to a table-wide basis. All the tests for trends were conducted at the 5-percent significance level. No inference has been made from the tables as a whole.

5. T. Fitz-Simons and D. Mintz, “Assessing Environmental Trends with Nonparametric Regression in the SAS Data Step,” American Statistical Association 1995 Winter Conference, Raleigh, NC, January, 1995.

6. Freas, W.P. and E.A. Sieurin, “A Nonparametric Calibration Procedure for Multi-Source Urban Air Pollution Dispersion Models,” presented at the Fifth Conference on Probability and Statistics in Atmospheric Sciences, American Meteorological Society, Las Vegas, NV, November 1977.

7. M. Hollander and D.A. Wolfe, *Nonparametric Statistical Methods*, John Wiley and Sons, Inc., New York, NY, 1973.

8. *Code of Federal Regulations*, 40 CFR Part 51, Appendix L.

9. *Code of Federal Regulations*, 40 CFR Part 51, section 51.151.